Saskatchewan Research Council

Saskatchewan Research
Council

A Theoretical Estimate of Hydro-Coil Energy Savings

Energy Conservation Technology for Buildings

A Theoretical Estimate of Hydro-Coil Energy Savings

A Calculation of the Energy Savings Achievable with the Hydro-Coil Retrofit Kit.

Prepared by:
D. Eyre
Saskatchewan Research Council
30 Campus Drive
Saskatoon, Saskatchewan
Canada
S7N 0X1

SRC Technical Report No. 136

SASK. LEGISLATIVE LIBRARY
JAN 11 1983
REGINA

November, 1982

SRC Publication No. E-825-55-B-82

CONTENTS

1. INTRODUCTION 1

2. DESCRIPTION OF THE HYDRO-COIL RETROFIT KIT 2

3. ASSESSMENT OF DIRECT FUEL SAVINGS 3

3.1 Defining the mild heating season 3

3.2 DHW efficiency and fuel consumption 8

3.3 Furnace efficiency and consumption 12

3.4 Energy savings of the Hydro-Coil system 13

4. ASSESSMENT OF SECONDARY FUEL SAVINGS 15

4.1 Cost of continuous air circulation 16

4.2 Comfort considerations 18

5. CONCLUSIONS 20

TABLE I. Mean daily temperatures (F), Saskatoon Airport, 1941-70 7

A device known as the Hydro-Coil Retrofit Kit is being advertised and marketed in Canada. It is manufactured in Saskatchewan. The advertising material claims that the device can reduce residential fuel consumption by as much as 35%, and this claim has created a certain amount of controversy. The claim is based on a theoretical analysis conducted by the manufacturers, who have submitted the analysis to Saskatchewan Research Council for an impartial assessment. This report gives the findings of this assessment.

The Hydro-Coil system consists essentially of a tubular copper heating coil. It is mounted, as a retrofit measure, in the warm air duct of a conventional furnace system, where it acts as a supplementary heating system with a capacity of about 20,000 Btu/h. The operation of the system is controlled by a thermostat. This thermostat activates a pump, which circulates hot water through the coil, from the domestic hot water heating system. The furnace fan circulates air through the ducts; this passes through the hydro-coil system, extracts heat from the coil and distributes it as space heating throughout the house. Essentially, therefore, the Hydro-Coil system is a device that uses the domestic hot water supply to give a moderate level of space heating.

The claimed fuel reduction is based partly on the method of operation of the system. The winter heating season can be divided into two parts: an intensive heating period, lasting from about mid-November to about mid-March, and a mild heating season in the fall and in the spring and early summer. In the mild heating season, with normal furnace operation, the furnace capacity is generally far too large for the needs of the house. As a result, the furnace operates at a low level of efficiency, and wastes a considerable amount of fuel. This fuel wastage can be reduced by using the Hydro-Coil system as the primary heating system in the mild heating season. Since the system draws energy from the domestic hot water tank - in tandem with the normal hot water usage - the domestic hot water heater has to operate more intensively. This raises the efficiency of the domestic hot water heater, and gives two types of fuel saving: first, the Hydro-Coil needs less fuel than the furnace to heat the house; secondly, the Hydro-Coil raises the efficiency of the domestic hot water heating system, and reduces the fuel that is normally consumed for water heating. In the intensive heating season the Hydro-Coil does not have enough heating capacity for the needs of the house. The heating systems therefore revert to normal operation in this period, with the furnace providing all the space heating and the domestic hot water heater serving only as a water heater. The fuel reductions of the Hydro-Coil system are therefore achieved entirely in the mild heating season.

According to the analysis conducted by the manufacturers, this mode of operation accounts for 25% reduction in fuel consumption. A further 10% reduction is claimed as the result of continuous air circulation, which is a feature of the Hydro-Coil operation. This claim is based on arguments about the increased comfort levels that can be achieved with continuous air circulation. These increased comfort levels allow the thermostat to be turned down slightly, which results in reduced heat loss from the house, and therefore reduced fuel consumption. The continuous air circulation also maintains a more uniform air temperature throughout the house, which may also make an indirect contribution to fuel savings. The claims for this further 10% fuel saving are based on technical publications. One of these publications asserts that the continuous operation of the furnace fan, at reduced speed, requires no more energy than a furnace fan operating at normal speed with normal intermittent furnace heating.

In calculating the Hydro-Coil fuel savings, this report follows the procedure used in the manufacturer's technical analysis. However, the report uses the basic data in a different way, and makes different assumptions to those in the manufacturer's analysis. It must be stated that houses vary considerably from one to the other, and any 'representative' figure will generally be subject to some variation. In places where 'reasonable assumptions' are made, these are generally shaded slightly in favour of the Hydro-Coil system, so as to present this system in the best possible light - and at the same time to protect this report against criticisms of unfair bias.

3.1 Defining the mild heating season

To determine the space heating requirements of a house we first have to know how quickly it loses heat, and how much of this lost heat is made up by free 'internal gains' that come from appliances, passive solar and the body heat generation of occupants.

We shall follow the manufacturer's analysis, and assume a fairly typical house with a heat loss coefficient (G) of 500 Btu/h/F. As a refinement on the manufacturer's analysis, we shall assume an average internal heat gain (I) of 5000 Btu/h. This represents the averaged effects of passive solar gain, occupant body heat and heat from electrical appliance usage. The figure is not untypical of a normal house subject to normal occupancy patterns.

We further assume that the house interior temperature is set at T_i = 70 F, and that the Hydro-Coil system delivers 20,000 Btu/h of heat. According to the manufacturer's test results, the actual figure is 19,200 Btu/h, but the assumed figure of 20,000 allows for reasonable variations from one house to another.

The house will need heat when the ambient temperature T_a falls below a value defined by the following expression:

$$T_a = T_i - I/G \qquad 1.$$

ie: $$T_a = 70 - \frac{5000}{500} = 60 \text{ F}$$

Therefore, when the ambient temperature falls below 60 F, the Hydro-Coil system will be required to supply heat. The Hydro-Coil system will continue to heat the house until the heating capacity of the system proves to be insufficient for the needs of the house. This will occur when the ambient temperature reaches a value defined by:

$$T_a = T_i - \frac{(I + H)}{G} \qquad 2.$$

where H is the heat output rating of the Hydro-Coil.

Thus:

$$T_a = 70 - \frac{(5000 + 20{,}000)}{500} = 20 \text{ F}$$

The Hydro-Coil system is therefore suitable for operation when the ambient (or atmospheric) temperature ranges from 20 F to 60 F. This temperature range therefore defines the 'mild' heating season over which the Hydro-Coil system operates.

The next step is to apply these temperature limits to actual meteorological records. These vary significantly from city to city across Canada, and there is no truly representative situation. The Hydro-Coil manufacturers have elected to use records for the city of Saskatoon in their analysis. This report will do the same, though it has to be borne in mind that the final result must be qualified as being based on Saskatoon meteorological conditions.

We now come to one of the main differences between this analysis and the manufacturer's: this analysis will use 30-year average meteorological date for Saskatoon*, whereas the manufacturer's analysis uses Saskatoon meteorological records for the 1981 calendar year.

---

* Daily Climatological Data, Saskatoon Airport, April 1941 to December 1970. Environment Canada, Toronto, 1971.

Generally, in analyses of this type, it is correct procedure to use long-term average climatic data - as being more representative of climatic behaviour over a period of several years. In selecting the climatic data for 1981, the manufacturer has unfortunately chosen an uncharacteristically mild year. The heating load for 1981 was 4989 Degrees-Celsius Days, as compared with a figure of about 6,000 for the 'average' climatic year. The demands placed on house heating systems in 1981 were therefore about 27% lower than in an average year. The choice of 1981 data therefore (and one presumes this was accidental) results in an untypically long mild heating season, and tends to make the Hydro-Coil look more effective than it would be in a more typical heating season.

The '30-year average' daily mean temperatures for Saskatoon are given in Table I. Boxes are drawn around the mild heating season, as defined by temperature limits of 20 F and 60 F. This Table gives the following information, which will be used in the subsequent analysis:

	N	$\sum T_a$	$\overline{T}_a$
Mild heating season: (Mar.21 to Jun.13 plus Aug.28 to Nov.16)	166	7286 F	43.89 F
Intense heating season: (Jan.1 to Mar.20 plus Nov.17 to Dec.31)	125	768 F	6.14 F
Total heating season: (Aug.28 to Jun.31)	291	8054 F	27.68 F

where:

N is the number of days in the season.

$\sum T_a$ is the sum of mean daily temperatures throughout the season.

$\overline{T}_a$ is the average ambient temperature throughout the season.

TABLE I. MEAN DAILY TEMPERATURES (F), SASKATOON AIRPORT, 1941-70

Date	MONTH											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	-2	6	27	47	55	62	67	60	47	32	15
2	0	5	5	30	45	57	63	66	58	48	32	14
3	-2	7	6	32	45	58	64	67	58	47	29	15
4	-2	7	6	33	47	59	64	68	58	47	31	13
5	-1	4	6	34	48	59	66	67	57	45	31	12
6	1	4	9	34	49	58	67	65	56	43	29	13
7	1	5	10	32	48	59	67	67	56	44	27	9
8	0	5	12	33	47	58	67	66	56	44	26	8
9	0	5	14	35	48	60	66	65	55	44	27	8
10	1	4	13	36	48	59	65	65	55	44	26	7
11	2	4	11	37	47	60	66	65	56	45	25	9
12	0	5	12	38	51	59	66	65	55	45	24	8
13	2	7	11	40	50	59	65	65	54	44	22	5
14	2	3	12	38	49	62	67	63	53	44	24	4
15	-2	3	15	40	50	61	68	64	52	44	23	7
16	-1	3	16	38	52	60	67	64	51	43	21	8
17	0	-1	18	38	54	60	65	63	52	42	19	5
18	-1	-2	19	40	52	60	67	64	51	42	18	5
19	-4	1	20	42	53	60	68	63	51	41	19	6
20	-5	2	20	40	54	61	67	63	50	39	18	5
21	-3	4	23	40	55	60	68	64	50	39	16	4
22	-5	6	22	40	55	62	67	64	50	37	16	3
23	-2	6	23	41	56	61	67	63	49	37	16	6
24	-2	7	23	42	56	61	66	63	48	37	18	8
25	-6	11	24	41	54	63	65	62	48	36	17	6
26	-6	12	25	41	54	63	66	60	48	36	15	5
27	-6	10	25	42	54	61	67	60	47	34	12	2
28	-5	10	26	44	56	60	67	59	48	36	12	1
29	-4	10	26	45	57	60	66	59	47	35	12	0
30	-3		29	47	56	61	65	59	47	36	14	1
31	-2		27		54		66	60		35		1

3.2 DHW efficiency and fuel consumption

a) Under normal operation:

A typical Saskatchewan household uses about 40 million Btu's of natural gas per year for domestic hot water heating. It can be assumed that domestic hot water usage is fairly uniform throughout the year . Therefore, a typical daily fuel consumption is:

$$\text{Daily DHW fuel consumption} = \frac{40 \times 10^6}{365} = 109589 \text{ Btu/d}$$

Not all of this energy actually goes into the hot water that comes out of the faucets; some of it goes up the flue and is lost entirely, and some is dissipated from the hot water tank and pipes, where it contributes to the space heating of the house.

The Hydro-Coil analysis , as submitted by the manufacturer, uses a reputable technical paper by Hoskins* as a basis for breaking down DHW energy use into its various components. This report uses the same paper to give the following figures:

Average DHW Energy Flow per Day

Hot water	56,986 Btu	(52%)
Flue loss	21,917	(20%)
Pilot flue loss	14,247	(13%)
Combined pipe & jacket losses.	16,439	(15%)
Total:	109,589 Btu	(100%)

The percentages are as given in Hoskin's paper*, and are applied to the daily fuel consumption assumed above.

Note that only 52% of the total energy consumption emerges as useful heat in the domestic hot water. The domestic hot water heater is therefore said to be 52% efficient.

---

* Hoskins, R.A. Energy and Cost Analysis of Residential Water Heaters. Oak Ridge National Laboratory, Oak Ridge, Tennessee, June, 1977.

If we assume a typically-sized DHW heater unit, with a rated input capacity of 36,000 Btu/h, the unit will operate for only 3.04 hours per day on average, if it consumes 109,589 Btu's per day.

b) Operation as combined DHW and space heater.

We now consider what happens when the DHW unit acts as a heating supply for both the domestic hot water system and the Hydro-Coil unit.

First of all, the hot water tank will operate at nominally the same temperature as in normal use, therefore the 'jacket losses' from the tank to the surrounding house air will be essentially unchanged.

Secondly, the household usage of hot water will not change as a result of the new mode of operation. The washing machine, showers, etc. will be used along much the same patterns as previously. The hot water will stand in the pipe distribution system for a similar length of time, and the pipe losses will therefore be much the same as before.

Thirdly, the pilot light will continue to operate continuously, as previously, and will dissipate the same amount of heat up the flue in each 24 hour period. Therefore, this loss will remain unchanged.

The flue losses are determined primarily by the efficiency of the combustion process and by the effectiveness of heat transfer from the hot combustion gases to the hot water tank. These parameters will not be altered significantly by the incorporation of the Hydro-Coil system. The flue losses will therefore be proportional to the total amount of heat delivered to the hot water tank. Since more heat is delivered when the Hydro-Coil is being used, the flue losses will increase in proportion.

The following analysis is used to calculate the flue losses:

During the mild heating season, the house will lose heat at a rate given by:

$$G \times (T_i - T_a) \quad \text{Btu/h}$$

The house will receive heat from internal gains, at a rate I Btu/h , and the Hydro-Coil system will have to supply the residual heating requirements, given by:

$$H = G \times (T_i - T_a) - I \quad \text{Btu} \qquad 3.$$

In the mild heating season, the mean ambient temperature (see table on page 6) is 43.89 F. Using previously defined values:

G = 500 Btu/h/F
I = 5000 Btu/h
T_i = 70 F

we obtain:

$$H = 8055 \text{ Btu/h} = 193{,}320 \text{ Btu/d}$$

This is an average space heating requirement for the mild heating season.

Therefore, in an average day, the DHW heater delivers the following heat to the hot water tank:

For space heating	193,320
For hot water	56,986
For jacket & pipe loss	16,439
Total:	266,745 Btu/d

Note that, although the jacket and pipe lose heat, this heat must first be passed from the combustion gases to the hot water tank.

In normal operation, the DHW heater delivers 73,425 Btu to the hot water tank (hot water plus jacket and pipe loss), and in the same daily period it loses 21,917 Btu's up the flue. Therefore, the ratio of

flue losses to heat delivered is:

$$\frac{21,917}{73,425} = 0.2985$$

As mentioned earlier, this ratio is determined by the efficiency of the combustion process and the effectiveness of the heat transfer process in the DHW heater unit. These mechanisms are not changed significantly by the incorporation of the Hydro-Coil, therefore the same ratio will apply when the Hydro-Coil is in use:

$$\frac{\text{Flue losses}}{\text{Heat delivered}} = 0.2985$$

ie: Flue losses = 0.2985 x 266,745

= 79,623 Btu/d

Using the foregoing information, we are now in a position to construct the daily energy flow of the DHW heater unit in its combined mode of operation:

Average DHW Energy Flow per Day

Hot water	56,986 Btu	(15.8%)
Hydro-Coil	193,320	(53.6%)
Flue losses	79,623	(22.1%)
Pilot flue loss	14,247	(4.0%)
Combined jacket & pipe loss	16,439	(4.5%)
Total:	360,615 Btu	(100.0%)

The efficiency of the DHW heater unit, in this mode of operation, is given by the ratio of total useful energy to total consumed energy:

$$\text{Efficiency} = \frac{(56,986 + 193,320)}{360,615} = 69.4\%$$

The introduction of the Hydro-Coil system therefore increases the efficiency of the DHW heater unit from its normal value of 52% to 69.4%.

The jacket and pipe losses contribute to the space heating of the house, and are therefore not losses when considered

within the house as a whole. They are included in the internal heat gains, mentioned earlier. Therefore, there would not be much point in insulating the DHW tank and the pipe distribution system, since this would add to the useful hot water heat but would reduce the contribution to space heating by the same amount.

Note that, with a rated DHW input capacity of 36,000 Btu/h, the DHW unit will now have to operate for about 10 hours per day instead of the 3 hours calculated for normal operation. Therefore, on average over the mild heating season, the DHW heater unit will operate with a 41.7% duty cycle. This means that the unit will still operate intermittently and will be subject to the penalties that are normally included in the 'seasonal efficiency' figure. The calculated efficiency of 69.4% does not include all the seasonal efficiency effects, and in practice the efficiency of the DHW unit should be somewhat less than this. However, in the interests of presenting the Hydro-Coil unit in the best light, the figure of 69.4% will be taken as a fairly good estimate. Even so, this disagrees with the figure of 80% used in the Hydro-Coil analysis. The 80% figure arises from incorrect extrapolation of the data presented in Hoskins report. The detailed analysis given in this section shows how the extrapolation should be conducted.

3.3 Furnace efficiency and consumption

Before comparing the Hydro-Coil system with a conventional furnace heating system, it is first of all necessary to establish reasonable values for furnace efficiency and fuel consumption.

It will be assumed that the furnace is considerably oversized in terms of the ratio of furnace capacity to house heating requirements. It will further be assumed that the furnace has a seasonal efficiency of 55% in the mild heating season, and 60% in the intensive heating season. These figures are consistent with generally-accepted data. What is more, they give an averaged efficiency of about 57% over the total heating season. This is less than the 60% assumed in the Hydro-Coil report, and tends to work more in favour of the Hydro-Coil system.

The total amount of energy consumed by the furnace over any period is given by:

$$E = (G \times (T_i - \overline{T}_a) - I) \times 24 \times \frac{N}{n} \quad \text{Btu} \qquad 4.$$

where:

- G is the heat loss coefficient (Btu/h/F)
- T_i is the house interior temperature (F)
- $\overline{T}_a$ is the average ambient temperature over the period (F)
- N is the length of the period, in days.
- I is the average rate of internal heat gain (Btu/h)
- n is the furnace efficiency.

Using previously defined values:

For the mild heating season:

$$E = (500 \times (70 - 43.89) - 5{,}000) \times 24 \times \frac{166}{0.55}$$

$$= 58.3 \times 10^6 \text{ Btu}$$

For the intensive heating season:

$$E = (500 \times (70 - 6.14) - 5000) \times 24 \times \frac{125}{0.6}$$

$$= 134.7 \times 10^6 \text{ Btu}$$

3.4 Energy savings of the Hydro-Coil system

The table on the next page assembles the various energy consumption figures calculated in this report, and uses them to compare a normal heating system against a Hydro-Coil system.

	ENERGY CONSUMPTION (million Btu's)	
	Normal System	Hydro-Coil System
Mild heating season (166 days)		
DHW heater	18.2(1)	59.9(2)
Furnace	58.3	nil
Intensive heating season (125 days)		
DHW heater	13.7(3)	13.7(3)
Furnace	134.7	134.7
Total energy consumption	224.9	208.3

Notes: (1) = 166 x 109,589
(2) = 166 x 360,615
(3) = 125 x 109,589

The use of the Hydro-Coil system therefore reduces the annual natural gas consumption of the house from 224.9 to 208.3 million Btu's. This corresponds to a reduction of 7.4%.

In the Hydro-Coil manufacturer's analysis, the end result is a calculated reduction of 25%. There is, therefore, a considerable difference between the Hydro-Coil estimate and the one in this report. The difference is due to several differences in the two analyses, but the two main differences are:

- Hydro-Coil's use of 1981 Climatic Data instead of 30-year average climatic data.
- Hydro-Coil's incorrect extrapolation of Hoskin's data when calculating the efficiency of the DHW unit in the Hydro-Coil operational mode.

The Hydro-Coil system is claimed to reduce energy consumption in two ways: the first is through the use of the DHW heater at a higher level of efficiency, as analysed in the previous section; the second is through the operation of the Hydro-Coil system with continuous air circulation. This second aspect is claimed to give a further 10% reduction in fuel consumption. This claim will be discussed in this section.

With respect to continuous air circulation, the Hydro-Coil claims are based predominantly on a technical paper by Mees*. The Mees paper makes a number of statements that are not in accordance with general practice, and would be vigorously opposed by many heating engineers. It is possible that Mees is discussing heating systems within the context of the more moderate climates and more moderate heating demands in the U.S.A. Whatever the reason, several of his assertions are demonstrably incorrect in a Canadian context. The Hydro-Coil claims are based partly on some of these incorrect assertions. The two most critical points will be discussed in detail.

4.1 Cost of continuous air circulation

In the normal operation of a heating system, the fan circulates air at relatively high speed whenever the heating system is operating. Instead of this intermittent high-speed operation, Mees proposes continuous air circulation at a lower air speed. He asserts that the lower fan power "more than offsets the cost of the additional length of blower operation" - taking into account "the high power consumption required for numerous starts".

To examine these statements, let us assume that the furnace has a one-third horsepower motor, and that the furnace has a fairly typical operation, consisting of 50 starts per day, with each start having an average fan 'on' time of 10 minutes. The fan therefore operates for about 8.3 hours per day, which is a fairly representative figure.

* Mees, R.F. Residential Heating and Cooling Systems Refrigeration Service Engineer Society, 1MG7-67, Des Plains, Illinois, 1959.

Each time the fan motor is started, it causes a start-up current surge. We shall make a fairly extreme assumption: that the surge lasts for three seconds and that the current is ten times the normal value in this period. The start-up surge is therefore equivalent to 30 seconds of normal motor running. Therefore, using the figures assumed above, the total electrical energy consumed by the fan in a 24-hour period is:

ON-time per cycle = 10 mins + 30 secs. = 0.175 hrs.
Number of cycles per day = 50
Total ON time per day = 8.75 hrs.

Fan power = 1/3 HP
Assumed efficiency = 60%
Electrical power rating $= \frac{746}{0.6} \times \frac{1}{3}$ = 414 Watts.

Total power consumption per day = 414 x 8.75
= 3623 Watt-hours
= 3.623 kWh.

This is the total power consumption per day when the furnace fan operates in the normal intermittent mode. If the fan were to operate continuously, and if it were to consume less than 3.623 kWh per day, it would need an effective electrical rating of:

$$\frac{3.623 \times 1000}{24} = 151 \text{ watts}$$

- or 0.12 HP at an assumed efficiency of 60%.

The effect of such a change in motor power is difficult to calculate with any accuracy, since it will vary according to the design of the ducting system. However, it is beyond dispute that such a change will result in a considerable decrease in the rate of airflow.

It is not clear, in the Hydro-Coil manufacturer's analysis, whether the continuous air circulation is to be used in the mild heating season or throughout the entire heating season. Therefore, we shall consider both possibilities.

a) Hydro-Coil operation:

If the fan operates continuously at a much-reduced air flow rate, the effectiveness and the heat output rating of the Hydro-Coil system will be considerably reduced.

b) Furnace operation:

If the fan operates continuously at a much-reduced air flow rate, the efficiency and the heat output rating of the furnace will be considerably reduced and the furnace heat exchanger may overheat to the point where the temperature limit thermostat interrupts the furnace operation. Such operation is potentially dangerous.

The Hydro-Coil analysis does not appear to consider either of these situations - the Hydro-Coil rating of 20,000 Btu/h is achieved with normal airflow rates, and this figure has not been downgraded in accordance with the reduced airflow rates of continuous air circulation.

To summarise: Mees' recommendations of continuous air circulation will reduce electrical power consumption only if the airflow rates are reduced considerably. If this is done, the rating and effectiveness/efficiency of the furnace and the Hydro-Coil system will be much reduced, producing a considerable increase in gas consumption and perhaps leading to a hazardous type of furnace operation. These problems can be overcome by using a two-speed fan that operates continuously at low speed, and cuts in at high speed whenever the Hydro-Coil system or the furnace are operating. However, if this is done, the originally assumed savings in electrical consumption will no longer apply. Neither mode of operation will produce the 10% savings estimated by Hydro-Coil; in fact they may increase total energy costs.

4.2 Comfort considerations

The Hydro-Coil analysis uses Mees' paper to support the argument that continuous air circulation improves the comfort level in the houses, and saves energy by allowing the thermostat to be turned down. This is true - to a certain extent and in some cases. The argument is based on the presumption that continuous air movement avoids temperature stratification and produces a more uniform air temperature throughout the house. The chance of this happening is far less then Mees appears to believe. Two factors are involved:

- In some houses, particularly 2½-storey or higher units, temperature stratification and poor air mixing will occur even when the fan is operating at normal speed. It is even more likely to occur when the air speed is much reduced - as is proposed with continuous air circulation.

- Since the Hydro-Coil is promoted as a retrofit kit, there is obviously an intention to apply it to older houses. In such houses the duct system is often poorly designed, with such things as short-circuiting cross-flows between warm air outlets and cold air registers. Such designs can defeat the objectives of improved air mixing.

Mees suggests that continuous air circulation will not improve the comfort level unless the warm air delivery temperature is 90 F or higher. In a typical Canadian house environment, with a cold return air temperature of about 65 to 68 F, this means that the heating system will have to operate continuously. The three conditions: uniform house air temperature at about 70 F, continuous air circulation and continuous heating are incompatible. They can occur only under rare combinations of conditions, when the heat loss of the house is exactly balanced by by all the heating sources. Generally, though, continuous heating at a fixed rate will cause the house temperature to rise or fall progressively, and will cause the house to become either uncomfortably hot or uncomfortably cold. The only way to avoid this is to control the heating system with the house thermostat, as is normally done. With continous air circulation, this means that the heat is cut off from time to time, but the air continues to circulate at 70 F or lower. This can actually decrease the comfort level.

In conclusion, the Mees paper contains a number of points that are either questionable or are capable of misinterpretation. These points have a direct bearing on the claims made by Hydro-Coil with regard to savings that result from continuous air circulation. From the foregoing analysis, it will be clear that such a technique has many ramifications that have not been considered in the Hydro-Coil analysis. When allowance is made for all the factors involved, the practice of continuous air circulation has questionable advantages and savings. Accordingly, Hydro-Coil would be ill-advised to promote this feature indiscriminately, and even more ill-advised to claim 10% energy savings.

SASK LIBRARY
JAN 11
REGINA

The manufacturers of Hydro-Coil have conducted a theoretical analysis on the performance of the Hydro-Coil Retrofit Kit, and have concluded that it is capable of reducing residential heating energy consumption by about 35%. This is the justification for the 35% energy reduction that is claimed in the product advertising. The 35% energy reductions are attributed to two factors: 25% arises from the improved seasonal efficiency of the domestic hot water heating system; 10% arises from the adoption of continuous air circulation techniques.

Saskatchewan Research Council has studied the Hydro-Coil analysis and has repeated the analysis in a more rigorous way, using data that are more generally accepted by the technical community for this type of calculation. In such an analysis it is necessary to make assumptions; all assumptions are reasonable or typical, and where possible have been shaded in favour of the Hydro-Coil system.

The Saskatchewan Research Council analysis shows that the Hydro-Coil system will give an estimated 7.4% reduction in total heating energy consumption. This reduction arises entirely from the improved efficiency of the domestic hot water heater when used also as a source of energy supply to the Hydro-Coil system. The practice of continuous air circulation, and the energy savings resulting from it, are shown to be questionable.

Accordingly, and bearing in mind the variability of house designs and heating systems, Saskatchewan Research Council recommends that the manufacturers and distributors of Hydro-Coil should claim no more than a 10% energy saving for the system. This 10% applies to applications in a prairie-type climate, and is the percentage saving on the total heating consumption - comprised of space heating and domestic hot water heating. A marginal increase over 10% might be attainable in warmer climates, but this report has not calculated the value for such conditions.

On looking through the Hydro-Coil analysis in detail, Saskatchewan Research Council has detected no obvious attempts to manipulate the end result. The calculations are a reasonable attempt to estimate the performance of the system. However, the analysis lacks scientific rigour and it is partly based on at least one technical paper of questionable authority and accuracy.